

STERILE SPECIES AND FERTILE HYBRIDS OF JAPANESE KNOTWEEDS ALONG THE RIVER KELVIN

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ABSTRACT

Fallopia japonica var. *japonica*, *F. sachalinensis* and their hybrid *F. x bohemica* occur along the River Kelvin in Glasgow. We describe their distribution along the river and in the surrounding area. All three taxa are gynodioecious, and in the Glasgow area we found only male sterile plants of *F. japonica* var. *japonica* and *F. sachalinensis*. Due to the absence of male fertile individuals of the parental taxa, we conclude that it is unlikely that the hybrid has arisen in situ.

INTRODUCTION

A wide range of plant species have been introduced (either deliberately or accidentally) to the British Isles, and have now become a significant component of our flora. While many of these introduced species occur in geographically restricted areas, others have become well established and widespread. Riparian habitats in particular have changed dramatically due to colonisation by some invasive alien weeds. One such species that has received considerable attention is the Japanese Knotweed - *Fallopia japonica* var. *japonica* (Houtt.) Ronse Decraene.

Fallopia japonica var. *japonica* was introduced to Britain from Japan in the early half of the 19th century. There is some debate as to the precise date, but the plants most probably came from a nursery in Leiden in ca. 1841 (Beerling *et al.*, 1994). Since its introduction it has spread to virtually all parts of the British Isles and its rapid spread coupled with the destructive capabilities of its rhizomes have led to it gaining notoriety as a troublesome weed.

A closely related species, the Giant Knotweed - *Fallopia sachalinensis* (F. Schmidt ex Maxim.) Ronse Decraene also occurs in Britain, and is again thought to be the result of a horticultural introduction in the 19th century, probably in the 1860's (Conolly, 1977).

Both *Fallopia japonica* var. *japonica* and *F. sachalinensis* are gynodioecious and can occur as either male-sterile (female) or hermaphrodite plants. In the hermaphrodite flowers, the stamens are (usually) longer than the perianth and the anthers are large, swollen and full of pollen. In the male sterile flowers the stamens are shorter than the perianth and the anthers are small, flat and empty. In Britain both female and hermaphrodite forms of *F. sachalinensis* have been recorded, but only male sterile plants of *F. japonica* var. *japonica* are known (Bailey, 1994). The implication of this is that *F. japonica* var. *japonica* is not capable of reproduction by seed in Britain, and that its spread is purely by vegetative propagation. Seed can be found on British plants of *F. japonica* var. *japonica*, but all seed examined so far is the result of hybridisation with closely related species such as *F. baldschuanica* (Regel) Holub, the Russian-vine, and *F. sachalinensis*. Although the majority of this seed appears to have *F. baldschuanica* as the pollen donor (Bailey, 1988), this hybrid very rarely becomes established in the wild. Only one such hybrid is known in Britain, in Haringey, Middlesex (Bailey, 1988).

The hybrid between *F. japonica* var. *japonica* and *F. sachalinensis* - *F. x bohemica* (Chrtek & Chrková) J. Bailey is, however, more widespread (Bailey *et al.*, 1996). In Glasgow all three of these taxa (*F. japonica* var. *japonica*, *F. sachalinensis* and *F. x bohemica*) are known to occur along the banks of the River Kelvin and we describe here their distribution and reproductive biology along the watercourse.

DESCRIPTION OF TAXA

Fallopia japonica var. *japonica* grows annually to a height of about 3m and forms dense clumps with stout, erect and often red spotted stems arising from strong rhizomes. The leaf blades are 5-12 cm long, 5-8 cm wide, broadly ovate, cuspidate at the apex and truncate at the base, coarse in texture and glabrous (Beerling *et al.*, 1994).

Fallopia sachalinensis, like *F. japonica* var. *japonica* is rhizomatous with stout, erect stems, but this species is somewhat larger and can grow up to 4m, and the stems tend to lack the red spotted appearance of *F. japonica* var. *japonica*. The basal leaves are much larger (28-40 cm x 18-24 cm) and ovate to oblong with a distinctive cordate base. The undersides of the leaves are scattered with long flexuous hairs (trichomes) (Bailey *et al.*, 1996).

The hybrid, *Fallopia x bohemica*, has an intermediate habit, growing from 2.5-4 m and its leaves are intermediate in both shape and size. The leaf tip is acuminate and the base is weakly to moderately cordate. The undersides of the leaves have numerous short hairs which are easily visible with a hand lens on the larger leaves (Bailey & Conolly, 1991). The stems show an intermediate level of spotting to the parental species. On morphological grounds, plants with red flecks on the stems, short hairs on the underside of the leaves, along with weakly cordate leaf bases are likely to be the hybrid. Some caution should be applied when using stem spotting as a character, as discolouration of *F. sachalinensis* stems (the taxon with which *F. x bohemica* is most likely to be confused) towards the end of the growing season can cause confusion.

Chromosome numbers

Chromosome counts for a number of individuals of all three taxa are given by Bailey & Stace (1992), and those from the British Isles are summarised in table 1. The difference in chromosome number of all three taxa is useful as it provides additional information to confirm identifications based on morphological characters.

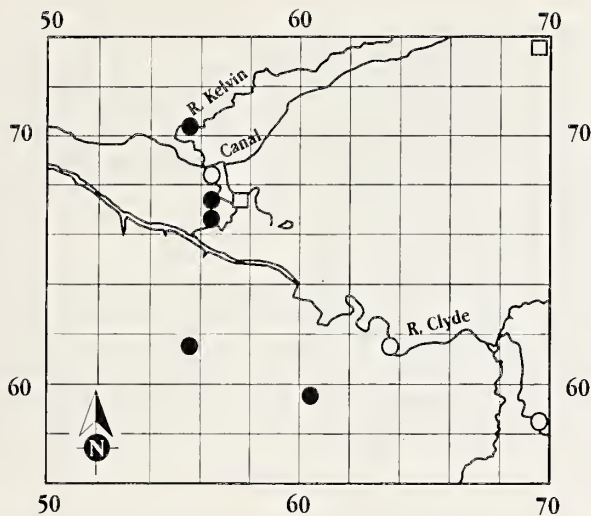


Figure 1.

Distribution map of *F. x bohemica* and *F. sachalinensis* in the Glasgow area and immediate surroundings.

Each square is a 4 square kilometre (= tetrad) block based on the Ordnance Survey National Grid. A sample of grid lines (50, 60, 70) is labelled for reference.

Topographical features include the Rivers Clyde and Kelvin and the Forth and Clyde Canal.

Black Circles = *Fallopia sachalinensis*
 White Circles = *Fallopia x bohemica*
 White Squares = both taxa

Three records from outlying areas are:
F. x bohemica NS/41.62 NS/54.78
F. sachalinensis NS/72.62

Table 1: Chromosome numbers of selected *Fallopia* species¹

<i>Fallopia japonica</i> var. <i>japonica</i>	2n = 88	Octoploid
<i>Fallopia sachalinensis</i>	2n = 44	Tetraploid
<i>Fallopia x bohemica</i> ²	2n = 66	Hexaploid

¹Taken from Bailey & Stace (1992)

²A chromosome number of 2n = 44 has also been recorded for *F. x bohemica*. This is from a cross between *F. sachalinensis* and *Fallopia japonica* var. *compacta* (which has 2n = 44). Neither *F. japonica* var. *compacta*, or the hybrid between *Fallopia japonica* var. *compacta* and *F. sachalinensis* are known from the Glasgow area.

DISTRIBUTION AND ECOLOGY OF *FALLOPIA JAPONICA* VAR. *JAPONICA*, *F. SACHALINENSIS* AND *F. X BOHEMICA* ALONG THE RIVER KELVIN, GLASGOW

In the Glasgow area *Fallopia japonica* var. *japonica* has been recorded from the majority of the tetrads (Dickson, 1991) and is very likely present in all 90. It is found forming small or large stands in a variety of habitats such as parks, gardens, railway banks, waste ground and along riverbanks. Its spread is remarkable given the lack of seed production, and its current distribution reflects disturbance and transport by human activities, although along water courses, dispersal by floating rhizome fragments seems likely.

Fallopia japonica var. *japonica* is well represented along the River Kelvin from the Killermont Golf Course south to the confluence with the Clyde. In 1996, during a walk from the Kelvingrove Museum along the riverside to the Garscube Estate, we rarely walked a distance of 100 m without noting a stand of this species. Further north, near Summerston and Balmore, the open and grazed banks of the Kelvin provide a less suitable habitat. The Kelvin downstream of the Killermont Golf Course provides a mosaic of habitats, but all have been more or less disturbed in recent history, and the river water, although cleaner now than in previous times, is still enriched by agricultural drainage and treated sewage. *F. japonica* var. *japonica* can form particularly large stands on the alluvial influenced river banks and it can also extend up the banks above the reaches of even the highest floods.

The localities of *Fallopia japonica* var. *japonica* along the Kelvin can be rich in associated species, reflecting the complex mixing of habitats. Native plants of the shaded river

edges include Wood Stitchwort (*Stellaria nemorum* L.), Comfrees (*Symphytum* spp.), Ramsons (*Allium ursinum* L.), Garlic Mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande), Lesser Celandine (*Ranunculus ficaria* L.), Rough Meadow-grass (*Poa trivialis* L.), Giant Fescue (*Festuca gigantea* (L) Villars) and Bistort (*Polygonum bistorta* (L.) Samp.). Alien species can be particularly well represented and typically include Few-flowered Garlic (*Allium paradoxum* (M. Bieb.) Don), Pink Purslane (*Claytonia sibirica* L.), Dame's-Violet (*Hesperis matronalis* L.), Sweet Cicely (*Myrrhis odorata* (L.) Scop.), Daffodils (*Narcissus* spp.), Hybrid or Spanish Bluebells (*Hyacinthoides* spp.) and the other notorious 'toublesome weeds' Indian Balsam (*Impatiens glandulifera* Royle) and Giant Hogweed (*Heracleum mantegazzianum* Sommier & Levier). Additional diversity is provided by a range of often ephemeral colonisers of alluvial deposits, and the more ubiquitous aggressive species such as Nettle (*Urtica dioica* L.), Creeping Thistle (*Cirsium arvense* (L.) Scop.), Cleavers (*Galium aparine* L.), Common Couch (*Elymus repens* (L.) Desv. ex Nevski) and Ground Elder (*Aegopodium podagraria* L.).

Fallopia sachalinensis and the hybrid, in contrast to *F. japonica* var. *japonica*, are rare in the local Glasgow area. Their distributions are summarised in fig. 1. The localities of *F. sachalinensis* are associated with the landscaped gardens of former Policy Estates, where it was presumably first introduced, although the plants have usually spread to the adjacent water courses where they may form large stands. It occurs in similar situations to, and shares associates with, *F. japonica* var. *japonica*, and can out compete it on alluvial influenced sandy river banks. The hybrid is also associated with old estates, where it may well have been introduced from nursery stock, but it also appears to show some of the invasive characteristics of *F. japonica* var. *japonica* as at Eastfield Burn and South Johnstone where it grows in disturbed areas, well away from an obvious local source.

Along the Kelvin, *F. sachalinensis* occurs in three large but very localised stands. The furthest upstream is at the Garscube Estate (NS/551.702), where a dense stand approximately 20 m long is present on the south bank of the river. The second stand is situated some 3.5 km downstream on the north bank by the Queen Margaret Drive road bridge (NS/

57.67). This is the largest stand of *F. sachalinensis* on the river, and stretches from the Botanic Gardens footbridge at (NS/569.675) to the road bridge (NS/571.675). This stand continues downstream to the weir at NS/571.674, although here it is less dense being interspersed with other Knotweed taxa. The third stand is on the north bank of the river at the Kelvin Way road bridge at NS/569.663. *F. sachalinensis* grows here in a few small discrete clumps along with *F. japonica* var. *japonica*. At this site the abundance of *F. sachalinensis* has recently been much reduced due to erosion of the river bank and chemical spraying.

Fallopia x bohemica was first recorded on the River Kelvin in 1993, immediately upstream of the footbridge at NS/568.680. At this site there is a stand approximately 15 m long on a steep embankment on the west side of the river. During the course of this survey we identified two further sites, although one of these was only a small isolated clump on the west side of the river, downstream of the footbridge at NS/569.680. The most extensive stand of this hybrid, and perhaps the easiest place to view it, is by the Queen Margaret Drive road bridge. Here, on the south bank of the river there are three large patches of *F. x bohemica* growing between the footbridge and the road bridge (NS/570.675) along with large stands of *F. japonica* var. *japonica*. On the north bank of the river, immediately downstream of Queen Margaret Drive road bridge, the hybrid grows over a 100 m stretch of the river bank down to the weir (NS/571.674-5). *F. x bohemica* grows here with both *F. sachalinensis* and *F. japonica* var. *japonica* and the differences in morphology between the three taxa can clearly be seen.

Table 2: Locality, sex and chromosome numbers of *Fallopia* species from the River Kelvin (F = male sterile; FM = hermaphrodite)

Locality	Grid Reference	Sex	Chromosome number
<i>F. x bohemica</i>			
Botanic Gardens (west bank)	NS/568.680	F	2n = 66
Botanic Gardens (west bank)	NS/569.680	FM	2n = 66
Botanic Gardens (north bank)	NS/571.674-5	FM	2n = 66
Botanic Gardens (south bank)	NS/570.675	FM	2n = 66
<i>F. sachalinensis</i>			
Botanic Gardens (north bank)	NS/569-71.674-5	F	2n = 44
Kelvin Way (north bank)	NS/569.663	F	2n = 44
Garscube (south bank)	NS/551.702	F	2n = 44
<i>F. japonica</i> var. <i>japonica</i>¹			
Botanic Gardens (north bank)	NS/571.674	F	2n = 88
Botanic Gardens (south bank)	NS/570.675	F	2n = 88

¹*F. japonica* var. *japonica* is abundant along the river, we include here only those localities from which we have cytological data.

Sex expression

All *Fallopia japonica* var. *japonica* and *F. sachalinensis* plants examined were male sterile. Both hermaphrodite and male sterile plants of *F. x bohemica* were found growing along the River Kelvin. The location of the plants examined and their sex is given in table 2.

Chromosome counts

Chromosome counts of all three taxa were made from mitotic root tip preparations as described by Bailey & Stace (1992), and the results are presented in table 2 and fig. 2. The chromosome numbers we obtained in all cases are in agreement with our identifications based on morphological characters and help confirm the identity of all three taxa.

DISCUSSION

The hybrid between *Fallopia japonica* and *F. sachalinensis* was first described in 1983 from the Czech Republic (Chrtěk & Chrková, 1983) and Bailey & Conolly, (1985) subsequently suggested the presence of hybrids between *F. japonica* var. *japonica* and *F. sachalinensis* in the British Isles. A recent survey by Bailey *et al.* (1996) indicates that *F. x bohemica* has been significantly under-recorded in the British Isles. In the Flora of Glasgow surveys, the hybrid was first recorded in 1991, and has presumably been over-looked or not distinguished from *F. sachalinensis* at locations such as Low Blantyre, Gartshore and along the Kelvin. A summary of the local records for *F. x bohemica* and *F. sachalinensis* is given in table 3.

Fallopia japonica var. *japonica* along with the other two taxa is now firmly established along the River Kelvin and as such they must be considered as important components of the local ecosystem. *F. japonica* var. *japonica* (and to a lesser extent the other two taxa) have received much bad press as a consequence of their vigorous growth and invasive abilities. A recent article describing these taxa in Britain was entitled "Japanese invader poised for the day of the triffids" (Nuttall, 1996). There have been conferences and local meetings concerned with the spread of Japanese Knotweeds (and other troublesome aliens) and there have been attempts at control, through chemical spraying, along the lower reaches of the Kelvin.

In recent years, however, some ecologists have called for a more long-term and dispassionate consideration of the ecological role of Knotweeds. Gilbert (1994) argues that *Fallopia japonica* var. *japonica* is "starting to play a valuable role in the ecology of urban areas". This view is supported by other authors and Dickson (1996) argued that Knotweeds and other alien plants should be seen as welcome additions to the British flora. *F. japonica* var. *japonica*, especially in its periodically disturbed riverside situations, is potentially an important climax vegetation. Winter flooding as well as providing additional nutrients, can remove dead stems and other debris, leaving open ground which can host a diverse array of vernal 'woodland' species; these are well adapted to early season growth before the *Fallopia* canopy shade becomes suppressive by mid-summer.

Fallopia japonica var. *japonica* is undoubtedly a very aggressive and damaging weed in many places, and often proves extremely difficult to control and eradicate, and is most unwelcome in parks and gardens. However, we consider

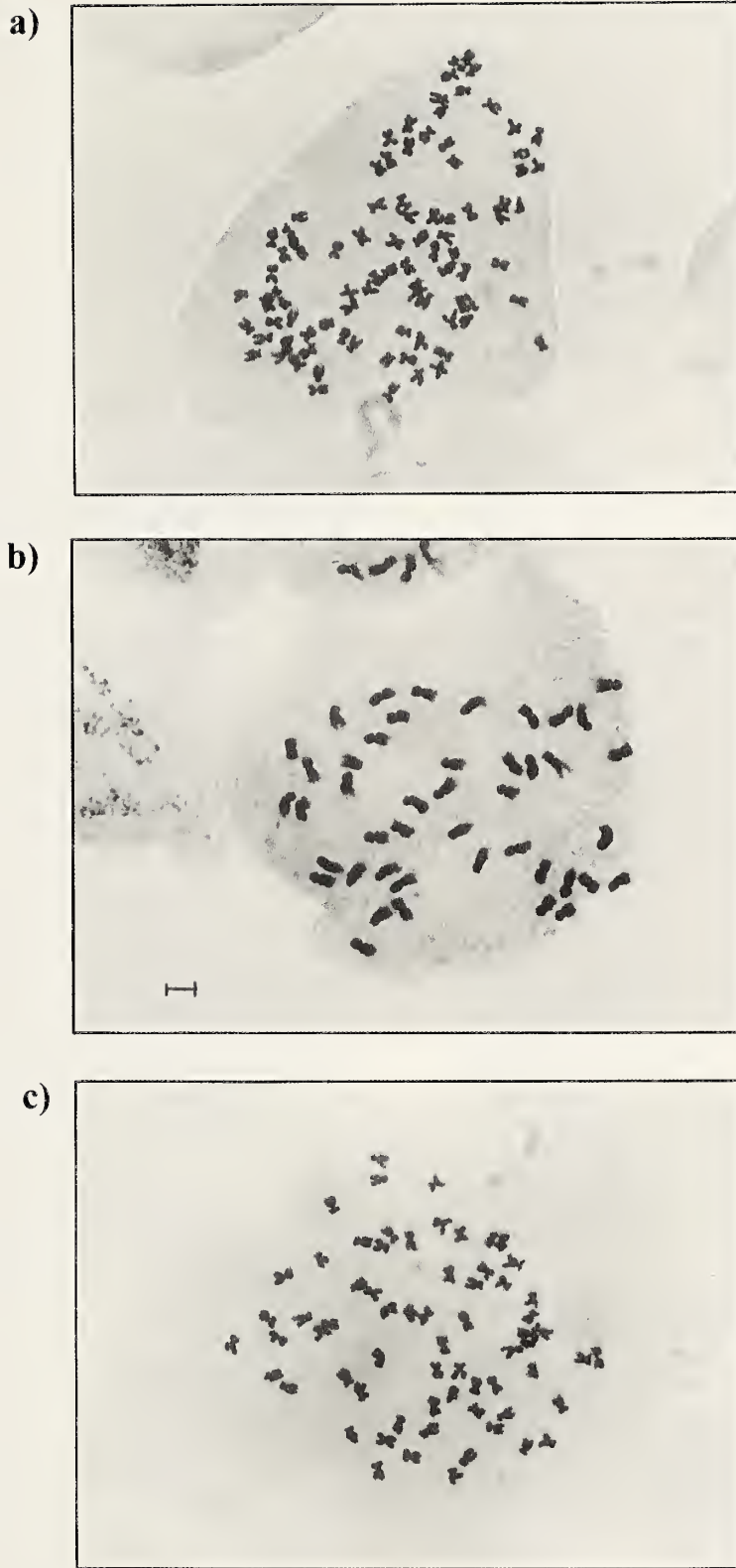


Figure 2 Mitotic chromosome preparations of a) *Fallopia japonica* var. *japonica*, b) *F. sachalinensis* and their hybrid, c) *F. x bohemica* Scale bar = 3 μ m

that along certain urban riverbanks, the plant could be viewed as providing valuable ground cover and does not necessarily constitute a serious problem, and in fact may be beneficial to the local ecology. Rivers, such as the urban stretch of the Kelvin, have suffered much disturbance in the past, but they

are naturally dynamic habitats, and the current development of the rich and varied flora along the Kelvin, both native and alien, should be welcomed.

Fallopia sachalinensis, *F. japonica* var. *japonica* and *F. x bohemica* form an unusual hybrid situation on the River

Table 3: Local Records of *Fallopia sachalinensis* and *F. x bohemica* (F = male sterile; FM = hermaphrodite)

Location	Grid Reference	VC	1st Recorder	Date	Sex
<i>F. sachalinensis</i>					
Pollok Park	NS/55.61	76	Dickson	1982	F
Castlemilk Glen	NS/60.59	77	Macpherson	1985	F
Botanic Gardens	NS/57.67	77	?	?	F
Kelvin Way	NS/56.66	77	?	?	F
Mill Bank	NS/72.62	77	Watson	1989	F
Gartshore Estate	NS/69.73	86	Dickson & GNHS	1987	F
Garscube Estate	NS/55.70	99	Watson	1988	F
<i>F. x bohemica</i>					
South Johnstone	NS/41.62	76	Watson	1994	FM
Eastfield Burn	NS/63.61	77	Macpherson	1993	F
Low Blantyre	NS/69.58	77	Macpherson & Lindsay	1991	F
Botanic Gardens	NS/56.68	77	Watson	1993	F
Botanic Gardens	NS/56.68	77	Hart, Hollingsworth & Watson	1996	FM
Botanic Gardens	NS/57.67	77	Hart, Hollingsworth	1996	FM
Dumbrook Loch	NS/54.78	86	Dickson	1994	FM
Gartshore Estate	NS/69.73	86	Hart, Hollingsworth & Watson	1996	F

Kelvin in Glasgow with the only male fertile taxon being the hybrid. Although we were not expecting to find any male fertile plants of *F. japonica* var. *japonica*, we were surprised, given the presence of *F. x bohemica*, that we found no male fertile plants of *F. sachalinensis*. It seems likely that on the River Kelvin *F. sachalinensis*, like *F. japonica* var. *japonica*, perpetuates by purely vegetative propagation. This raises the question as to how the *F. x bohemica* plants originated, as hybridisation between two effectively female populations of the parental species is impossible. We offer two possible explanations. Firstly that there either is, or once was, a male fertile *F. sachalinensis* in the area, unknown to us, and this served as the pollen donor to form the hybrid. A second possibility is that the hybrid has arisen elsewhere and its distribution along the River Kelvin with its parents is coincidental. We have checked all Glasgow records of *F. sachalinensis* and as yet have found no male fertile plants (table 3). We also examined all *F. x bohemica* populations in the Glasgow area, and the distribution of the sexes is shown in table 3.

Given the absence of male fertile *Fallopia sachalinensis* in the region, we have no evidence to suggest that *F. x bohemica* has arisen locally, and it seems likely that the hybrid has been introduced to the Glasgow area.

Furthermore, as we have found evidence for at least two clones of *F. x bohemica*, (one hermaphrodite and one male sterile), it is possible that it has been introduced on multiple occasions. The association of this taxon with the Botanic Gardens could well be far from coincidental, and it is quite possible that different clones have been introduced here. It should be borne in mind, however, that as the genetic basis of the difference between the male sterile and hermaphrodite forms is still unknown, we cannot rule out that the male sterile *F. x bohemica* plants are second generation hybrids that have arisen *in situ* from the hermaphrodite plants of *F. x bohemica*. Molecular studies using DNA fingerprinting are currently underway to try to determine the extent of the clonal diversity of all three taxa and to gain a deeper insight into their reproductive history.

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